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PRINCE MOHAMMAD BIN FAHD UNIVERSITY

College of Engineering

Department of Mechanical Engineering

Spring - 2019

Senior Design Project Report

Design of Atmospheric Water Generator

**In partial fulfillment of the requirements for the
Degree of Bachelor of Science in Mechanical Engineering**

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Abstract

Many people in the world do not have access to clean fresh water. Also, drought has plagued many regions in the world, devastating crops and brought societies to the brink of collapse (Such as the severe drought in the city of Cape Town in South Africa right now). The UN has projected that the demand for fresh water will exceed the supply by 40%, so it is time for engineers to step in and find sustainable solution to the water crisis. Our project is trying to address the water shortage problem. Huge amount of water vapor is present in humid atmosphere, especially in Al Khobar where the humidity reaches high percentage, so it is imperative to design atmospheric water extraction and collection system. We will use solar cells and thermoelectric materials to design innovative, simple and inexpensive atmospheric water generator. This water generator could be used in homes to provide people with fresh water or can be used in farms for irrigation purposes.

Acknowledgement

As a senior year graduating students of our institute, we would like to pay our utmost gratitude and respect towards our project supervisor and advisor Dr Mohammad El-Mehdi Saleh for his exceptional support and expertise in helping us achieving the project objectives and successfully building a working prototype of our project. Moreover, we would also like to thank the Chair of Mechanical Engineering Department, Dr. Faramarz Djavanroodi in motivating us and giving us a boost in morale to work dedicatedly in completing our Bachelor's program by successfully fulfilling the most important requirement of the whole degree, which actually is our senior design project. Also, from deep within our hearts, Dr. Panos really guided us and kept a constant check on us by successfully meeting the deadlines for the required deliverables related to our project and we would like to pay our respect and thanks for his kind generosity.

Secondly, we would like to thank the technicians who helped us in putting together the prototype for testing and many more because it actually determines the proper completion and successful achievement of the objectives we aimed for.

List of Acronyms

P	Power
$\dot{m}$	Mass Flow Rate
v	Velocity
A	Cross Sectional Area
V	Volume
w	Humidity Ratio
m	Mass
ρ	Density
T	Temperature
I	Current
V	Volts
R	Thermal Resistance
K	Thermal Conductivity

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Chapter # 1: Introduction

1.1 Project Definition

Looking into one of the most prominent concern in the developing and under-developed world, water crisis is one of the main problems that still persists since it is one of the most essential, basic and important requirements for a healthy body and the availability of clean water is really scare in these areas. In order to rectify and diminish these persistent problems related to water availability, especially in the coastal regions, where the sea is accessible but no means of cleaning that water for a good use. In this regard, our team will be working on in developing a water generator which will condense the suspended water molecules (humidity) from the atmosphere into liquid phase water. But, in order for this project to catch up, it must be applicable in the regions like the Eastern Province in the coastal cities where the humidity conditions can rise up to as much as 60% in the atmosphere during peak times. This water generated could be then used in various applications.

1.2 Project Objectives

Our project is based on the following objectives:

1. Design a system to convert the air into water to use it at homes to provide people with fresh water or can be used in farms for irrigation purposes.
2. Preserving the limited water supply in Saudi Arabia.
3. Take advantage of humid weather by generating water.
4. Using the thermal electrical (Peltier) as refrigerate to condense the air.

1.3 Project Specifications

Since the project will mostly be composed and built of standard components available from the market, there still are some fabrications we would need to perform in order to make our prototype look professional and presentable. Additionally, the components used in our system and their dimensions are;

Component	Dimension
2 Thermoelectric Cooler (Peltier)	4 x 4 cm (288 W & 6 A)
Galvanize steal	56 cm x 15 cm
Fan	12 cm x 12 cm
Base	50 cm x 40 cm

Table # 1: System Specifications

1.4 Project Applications

In terms of sustainability, many projects are looked in its application in the real world which would test the dependability and durability of a concerned system. Similarly, our project serves to be remarkable in these aspects because water is a necessity of life and availability of clean water can be consumed in a lot of different aspects;

- The air water generator can be used to generate clean drinking water by attaching a filtration unit to it.
- The air water generator can be used at an industrial scale also, such as in Jubail Industrial City, it can be used at a larger scale to generate enough amount of water to meet the needs of the workers for drinking and domestic usage.
- These water generators can also be placed in sectors such as Industrial, Residential and Commercial where water can be used to good use.

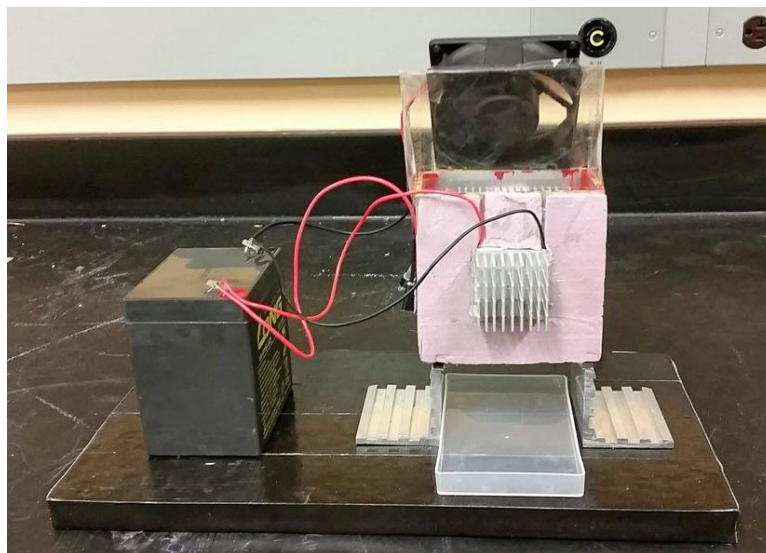


Figure # 1: Air Water Generator Prototype [1]

Chapter # 2: Literature Review

2.1 Project Background

Our atmosphere contains at least some concentration of water in the air, not necessarily in the liquid but they exist as vapor or moisture in the air. Now, this concentration can exceed a lot if considering the ambient conditions on coastal areas and even very close to the shore due to the natural phenomenon of the water cycle that always persists. On the other hand, this moisture content in the air can be extracted and stored and be put to good use since in the continent of Africa especially, there is a huge problem in dealing with the availability of clean drinking water.

Since, there was a report published by U.N. in the investigation of water scarcity, it was found out to be that by the end of 2050 around 5 billion people are vulnerable to suffer from water scarcity depending on the rate of climate change nowadays. Also, a human consumes about 4600 cubic km of water every year, from that whole 70% goes to agriculture, 20% goes to the industry and the remaining 10% is consumed by households. Because of the industrial pollutions being contaminated the water, the problem has been worsening since the 1990s which is adding more stress to the demand of making sure that there is ample water available for the mankind to consume and meet their needs. But, if it keeps on going without any considerations and preventive measures, dry regions will get drier, wet regions will get wetter and the water will soon be a lost jewel that kept everyone alive and living healthy [2].

Based on such concerns, our team, just like any other environmentalist, has come up with a plan of devising a atmospheric water generator which will be working purely by the help of solar power. As water is an essential necessity for living, it is our duty as residents of this world to take of the resources and refrain from wasting them.

2.2 Previous Work

In regards to water projects for developing and under-developed countries such as in Africa, numerous amounts of work and projects have been done to help the African people survive and meet proper nutrition. World desperately needs alternative “water cultivation” methods and producing water from air is one of the most viable and sound solutions presented as the world’s fresh water needs increase daily. This technology has ability to meet and fill the growing demand for economical, safe, great tasting drinking

water in a clean drinking water is to health and wellness for people everywhere. We have designed and developed a prototype system for removing clean (potable) drinking water from air using a traditional power grid. Use a traditional power grid to generate electricity; use electricity to cool air (or increase pressure) resulting in condensation of water; capture water vapor from air that condenses into water to obtain 99% pure and safe drinking water from the moisture in the air. Implementation of process using most efficient and cost-effective method is also an important concern in the project [3].

Similarly, a research paper explains how the global water challenge is the motivation to find new sources of drinking water. The Earth's atmosphere holds enormous amounts of water in the form of vapor which could serve for that purpose. Various technologies already exist, and are described here, that make use of the atmospheric water vapor as freshwater source. Yet, for active cooling technologies, humidity harvesting is an energy intensive application, as water vapor is embedded in ambient air. Therefore, a method is introduced that uses water vapor selective membranes to concentrate the water vapor prior to the cooling process. The successful implementation of such membrane separation processes in other applications (flue gas dehydration) is described and the main challenges concerning their use in humidity harvesting are stated. The way these challenges will be dealt with is described in the outline of the thesis, where the content of the individual chapters is stated briefly [4].

Also, An Atmospheric Water Generator is an appliance that employs dehumidification/condensing technology that extracts water from the humidity in the air. The water is then filtered and purified through several filters including carbon, and reverse osmosis, and UV sterilization lights. The result is pure drinking water from the air. An Atmospheric Water Generator Works on the same principle as a refrigerators and air conditioners i.e. on the principle of cooling through evaporation. The Atmospheric water generator works by converting atmospheric air to pressurized air using a Compressor and then this air is then passed through Condenser pipes which decreases its temperature to dew point. The air condenses to liquid and is passed through a filtration system and it is then stored in a tank. The major aim or objective of our project is to provide safe and clean drinking water to those areas which are facing water shortage problems or where water transportation through regular means is expensive (especially rural areas). Our project hopes to reduce this problem by

providing an atmospheric water generator that will run via bicycle-gear arrangement or stand-alone renewable source of energy i.e. either solar or wind [5].

2.3 Comparative Work

For our team to get a proper insight and an approach to successfully execute a plan in building and developing our project. Since, the project will mainly assist solar panel to power the Peltier (Thermoelectric Cooler) and the fan, below is a presentation of a comparison of how the previous projects were executed.

Firstly, the paper presents the method to develop a water condensation system based on thermoelectric cooler. The system consists of cooling elements, heat exchange unit and air circulation unit. A solar cell panel unit with a relevant high current output drives the cooling elements through a controlling circuit. Atmospheric Water Generator is a device that can convert atmospheric moisture directly into usable and even drinkable water. It is such a device which uses the principle of latent heat to convert molecules of water vapor into water droplets. It has been introduced a bit before, though it is not very common in India and some other countries. It has a great application standing on such age of technology where we all are running behind renewable sources. This paper also describes the experimental results and the system's performance [6].

Secondly, a group of students conducted a senior design project which was to design and prototype an atmospheric water generator. This is device which produces drinkable water from humid air with an emphasis on energy efficiency and renewable energy sources. The first requirement is that the water produced is safe to drink. This requirement is vital because engineers must be socially responsible and take precautions so that society is not harmed by any products, they design. The approach they took into consideration of extracting water from humid ambient conditions were by use of a Desiccant and then by extracting water chemically filter and the last approach was to use a Peltier or a Thermoelectric Cooler [7].

Chapter # 3: System Design

3.1 Design Constraints and Design Methodology

3.1.1: Geometrical Constraints:

Air water generators can be made and designed of in any size as required by the end user. But, since we are targeting a more portable, easy to carry and transport approach. We have to ensure that it does not exceed a volume of 30 cubic meters. For that aspect, the constraint we had to face was to select a thermoelectric cooler that was small, a fan module, a custom-made aluminum heat sink to condense the atmospheric water vapor and on top of that a galvanized steel that can be used to install the thermoelectric inside it. In addition, there is a fan at the top of the galvanized steel to compress the ambient air inside the system. Therefore, these geometrical constraints are the designing elements to get our prototype made.

3.1.2: Sustainability:

Our prototype works purely by means of a thermoelectric cooler and an aluminum heat sink for condensing the water in vapor state into liquid drinkable state. The sustainability problems our prototype can face is with the thermoelectric cooler and the aluminum heat sink since the Peltier can degrade over a considerable amount of time. Similarly, the aluminum heat sink could also face corrosive attacks as it will be exposed to the humid conditions which is very favorable for materials such as the aluminum to be a very favorable site for corrosive attacks.

3.1.3: Environmental Concern:

As our project aims to provide safe, clean and healthy drinking water from the humid atmosphere in regions where conditions can detect as much as 50% and above humidity in air. Environmentally, this project does not pose any kind of threat instead it uses the atmospheric vapor content to condense and provide drinking water which is extremely beneficial. As, water is a major problem and concern in many developing and under-developed regions, it can contribute in using those environmental conditions for the betterment of the population.

3.1.4: Social Impact:

Water is a basic necessity of life and as students, having an awareness about the conditions in which people are surviving with very limited water supply and humid conditions, this project can play a very positive role in the society where there will be an ample supply of water just from the humid living conditions. They would not even require to strive hard or do some extra effort to get water from sources which are out of their reach or unaffordable.

3.1.5: Economic:

For a country, where water is scarce, these types of systems can help the overall economic conditions as well as the living conditions for many people. As, there will always be available of water, these types of generator will always be present in extremely close vicinity to the population or even at homes. Investment in such kind of projects can bring a lot of benefits when it comes to economy. As people will not be water deficient, they won't incur any water related disease and will not even have a chance of visiting a hospital which will save the government some money. So, in the long run, economic impacts are very positive.

3.1.6: Safety:

As there are no big and dangerous components plugged into our water generating system, there really isn't a big safety concern. However, we surely have kept safety as our priority by using components with no safety threats and risks apart from a D.C. source which will be used to power the generator, or an inverted A.C. source could be used for domestic purposes.

3.1.7: Ethics:

Successful choosing a topic of concern which is being faced in many developing and under-developed countries. There have been many works done relevant to our project topic. However, each of those generators used a different technique in generating water and each had its own pros and cons. However, these projects have given us the motivation and an insight to apply their knowledge and proposed theory in achieving the task we desire.

3.2 Engineering Design Standards

Since our project contains components that are readily available in the market, as far as the engineering standards are concerned, they are dependent on the manufacturers producing such components. However, below is the list of components with their grade/ standards enlisted.

<i>Components</i>	<i>Engineering Standards</i>
Galvanized steel	Galvanized Steel Z120
Base of Wood	SS-EN 1611-1
Aluminum heat sink	Aluminum alloys 6060

Table # 2: Engineering Standards

3.3 Theory and Theoretical Calculations

3.3.1: The Power of the System

- To find the Power of the system:

$$P = I V \quad (3.1)$$

Where I is the current, V is the voltage.

3.3.2: The System Analysis:

- To find unit energy per letter of water

$$U_e = \frac{(P_e \Delta T)/100}{w} \quad (3.2)$$

- Where U_e = unit energy per letter (KJ/L)

P_e = power consumption (W)

ΔT = time in second

W = water productivity (L/day)

- To find the dew point temperature

$$T_d = T - ((100 - RH)/5) \quad (3.3)$$

Where T is the ambient temperature, RH is the relative humidity.

3.3.3: The Result

- The power of the system by using equation (3.1)

$$P = 4(6 \times 12) = 288 \text{ W}$$

- unit energy per letter by using equation (3.2):

By assuming different value of W:

P_{el} (W)	ΔT (Second/day)	W (L/day)	Ue (KJ/L)
288	86400	0.5	49766.4
288	86400	1	24883.2
288	86400	1.5	16588.8
288	86400	2	12441.6
288	86400	2.5	9953.28

Table # 3: the energy per letter

- the dew point temperature by using equation (3.3)

T (C)	RH (%)	Td (C)	T (C)	RH (%)	Td (C)
25	40	13	35	40	23
	50	15		50	25
	60	17		60	27
	70	19		70	29
	80	21		80	31
30	40	18	40	40	28
	50	20		50	30
	60	22		60	32
	70	24		70	34
	80	26		80	36

Table # 4: the dew point temperature

3.4 Product Subsystems and selection of Components

3.4.1 Peltier Thermoelectric Cooler

Since our project is aimed towards domestic usage and purposes, we have decided to use a Peltier Thermoelectric cooler which actually has some very good thermodynamic properties when it comes to cooling a chamber in a very effective manner using a little as 12 volts D.C source. Also, since it is available in many sizes from the market, we managed to choose two small ones which cover an area of about 0.16 square centimeters.

11.4.1 Fans

In order to properly cool down the humid atmospheric air, we have to make a use of an electric fan which also easily available in the market. This fan will be mounted on the outer side of the galvanized steel (where the water will be condensed and stored in a reservoir) and uses a power source of 12 volts to be successfully and effectively functional.

11.4.2 Aluminum heat sink

The Aluminum heat sink we agreed on using was utter based to successfully accomplish the proper insulation of heat and heat transfer to support the objective of our experiment in order to make it effective enough to work properly. Moreover, it was rendered in such a way that no humidity rests on the walls of it and trickles down in the container for water collection.

11.4.3 Galvanized steel

We ensure to use galvanized steel in order to corrosion and help with fabrication our prototype in such a way that it completely does the purpose of what we are using it for. Furthermore, since galvanized steel is readily available in the market, we were able to use it with minor fabrications to accommodate as an anchor and a stand to hold our prototype at a vertical angle to allow water to trickle down the mechanism and into the water reservoir.



Figure # 2: Air Water Generator CAD Model

3.5 Manufacturing and Assembling (Implementation)

In terms of implementing our prototype's final design, we have managed to make a get a very precise and concise type of assembly by Indenting and welding the galvanized steel in the desired shape. This will be kept open from one of the faces in order to place a water collecting container. Additionally, since there is no complexity and sophistication in our project or parts, due to having a plug and play configuration. We have managed to get it in one piece by purely connecting in a proper manner where there is no risk of short circuits and open loops. As, this is how the prototype designing and assembly was implemented with respect to our project, we figured out that we can successfully accomplish this milestone with as little hassle as possible.

Chapter 4: System Testing and Analysis

4.1 Experimental Setup, Sensors and data acquisition system

4.1.1: Humidity Meter

As our project is mainly concerned with the applications of HVAC systems in compliance with heat transfer principles. We had to make use of a handheld humidity meter that has the capability to determine the moisture content in the air. This also provided us with results and data that we can use further on to calculate the amount of water being generated from our system over a considerable amount of time.

Moreover, the tachometer has following specifications;

Specifications:

- Fast respond time and high accuracy
- Dewpoint temperature: -20~+80C/-4~+176F
- Wet bulb temperature: -20~+80C/32~+176F
- Maximum hold and data hold function
- Microprocessor based design, dual display with temperature/humidity
- Auto power off, disable sleep mode, mini size
- Display: Large 4-1/2 dual digital LCD display
- Sensor type: A single chip relative humidity and temperature multi snesor module comprising a calibrated digital output
- Respond time: %RH 10s (90%at +25C)
- Accuracy: 64-82F
- Sampling rate: 2.5 sample per second
- Polarity: Automatic negative polarity indication
- Over-range: "OL" makes indication
- Operating/storage conditions: 32-104F; <80%RH non-condensing/14-140F; <80RH non-condensing
- Measurement range: Humidity-0-100%RH; temperature: -20~+80C
- Resolution: 0.01%RH; 0.01°C/0.01F
- Humidity accuracy: ±3%RH (at 25°C, 20-80%RH); ±3.5RH(other range)
- Air temperature accuracy: ±0.5C/C0.9 F(at 25C); ±0.8C/±1.5F(other range)
- Dimension: 175*58*35mm



Figure # 4: Humidity Meter

4.1.2: Digital Thermostat

In order to properly manage temperature deviation within our system we had to ensure proper operation of our system, the use of digital temperature sensor was used which would help us control the humidity level and the amount of temperature that would require our system to generate enough water for consumption in the most effective and efficient conditional parameters. Furthermore, the digital weight scale used to measure the data in the table above has following specifications;

Specifications:

- All-purpose Temperature Controller STC-1000
- Mounting size: 71*29mm
- Autoswitch between refrigerating and heating
- Retrun difference value
- Voltage:220 V AC $\pm$ 10%

- Frontpanel size 75(L) ×34.5(W) mm
- Mounting size: 71(L) ×29(W) mm
- Product size 75(L) ×34.5(W) ×85(D) mm
- Sensor cable length:2m (include the probe)
- CE approval
- Temperature measuring range: -50~99°C
- Resolution: 0.1°C
- Accuracy: ±1°C (-50~70°C)
- Sensor error delay: 1 minute
- Power supply: 110V-220VAC±10%, 50/60Hz
- Power consumption: ≤3W
- Sensor: NTC sensor (1PC) cable 2 M, 10KΩ/25°C, B vale 3435K/(25°C85°C)
- Relay contact capacity: Cool 10A/250VAC; Heat10A/250VAC
- Ambient temperature: 0~60°C
- Storage temperature: -30~75°C
- Relative humidity: 20%~85% (No condensate)



Figure # 5: Digital Weight Scale

Testing Parameters	
Humidity Meter	To obtain the output moisture content
Digital Thermostat	To control temperature

Table # 5: Testing Parameters

4.2 Results, Analysis and Discussion

Data obtained from performing the setups in order to get our system performance figures, following tables have been compiled which illustrates the results of how much water is being generated by our system.

Experiment #	Time (hr)	Tambient (C)	RH (%)	Amount of water (L)
1	2	24	51.73	0.048
2	2	22	52.66	0.05
3	2	22	47.46	0.04
4	2	24	49	0.043

Table # 6: Measured Data from System

- Calculated amount of water in one day

Experiment # 1: $0.048 \times 12 = 0.576$ L/day

Experiment # 2: $0.05 \times 12 = 0.6$ L/day

Experiment # 3: $0.04 \times 12 = 0.48$ L/day

Experiment # 4: $0.043 \times 12 = 0.516$ L/day

- The average amount of water in one day:

$$w = \frac{0.576 + 0.6 + 0.48 + 0.516}{4} = 0.543 \text{ L/day}$$

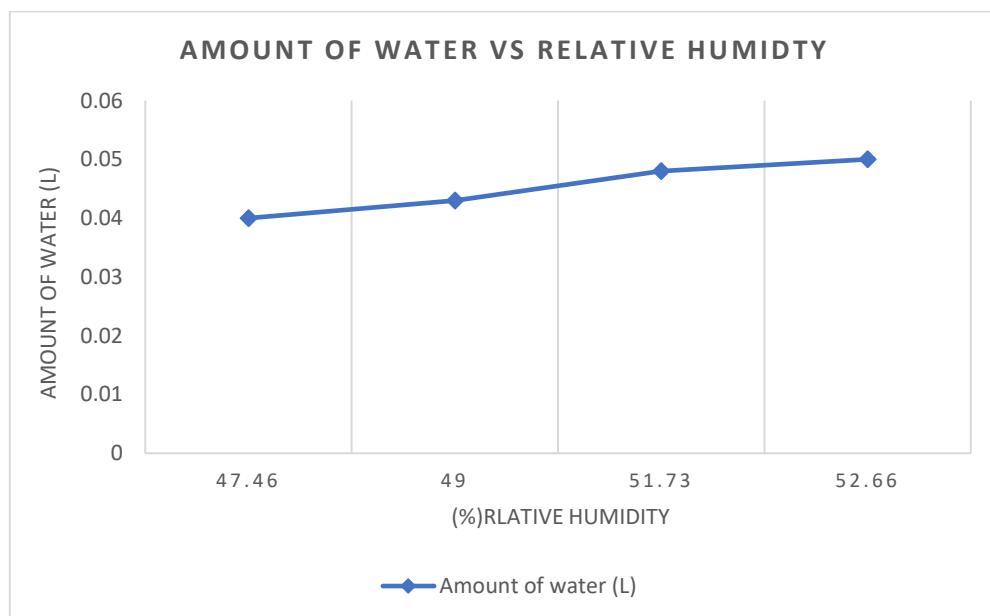


Figure # 7: Amount of Water VS Relative Humidity Graph

From figure number 7, it has been illustrated very prominently that as the value of Relative Humidity increases, the amount of water increased.

However, when it comes to calculating the unit energy, following parameters are considered and used.

$$U_e = \frac{(P_e \Delta T)/100}{w} \quad (3.2)$$

Where U_e = unit energy per liter (KJ/L)

P_e = power consumption (W)

ΔT = time in second

W = water productivity (L/day)

$$U_e = \frac{(288 \cdot 86400)/1000}{0.543}$$

$$U_e = 45825.41 \text{ kJ/L}$$

The above result shows that the amount of power consumed by our system to produce a liter of water is 45825.41 kJ/L.

Chapter 5: Project Management

5.1 Project Plan

The project comprises of various tasks that are assigned to each group member in an equal manner, to ensure fairness between the members. Each member was given a specific task that needed to be completed within a certain amount of time.

The times and dates listed in the Gantt Chart were followed to ensure consistency and quality of the work done by the group members.

Table 5.0 displays the number of tasks done alongside with the number of days it took for that specific task to be completed.

S. No.	Tasks		Start	End	Duration
1	Ch. 1: Introduction		23.01.2019	27.01.2019	4 days
2	Ch. 2: Literature Review	Project Background	30.01.209	03.02.2019	4 days
		Previous Work			
		Comparative Study			
3	Ch. 3: System Design	Design Constraints & Methodology	08.02.2019	19.02.2019	9 days
		Engineering Design Standards			
		Theory & Theoretical Calculations			
		Product Subsystems & Component Selection			
		Manufacturing & Assembly			

4	Ch. 4: System Testing & Analysis	Experimental Setup, Sensors & Data	10.03.2019	29.03.2019	19 days
		Results, Analysis & Discussion			
5	Ch. 5: Project Management	Contribution of Team Members	06.04.2019	09.04.2019	3 days
		Project Execution Monitoring			
		Challenges & Decision Making			
		Project Bill of Materials & Budget			
6	Ch. 6: Project Analysis	Impact of Engineering Solution	05.04.2019	08.04.2019	3 days
		Contemporary Issues Addressed			
7	Ch. 7: Conclusion & Recommendation	Conclusion	07.04.2019	09.04.2014	2 days
		Future Recommendation			
8	Design of Prototype		08.02.2019	11.02.2019	3 days
9	Parts Purchased		11.02.2019	27.03.2019	46 days
10	Manufacturing		20.03.2019	27.03.2019	7 days
11	Testing		28.03.2019	04.04.2019	7 days

Table 7: Tasks and their Duration

Table 7 identifies the task and the duration for each task.

S. No.	Task	Assigned Members
1	Introduction	All members
2	Literature Review	Abdullah and Fawaz
3	System Design	Moaad & Fawaz & Abdullah
4	Testing and Analysis	Abdullah & Omar
5	Project Management	All members
6	Project Analysis	Moaad
7	Conclusion and Recommendation	Omar
8	Design	Moaad & Fawaz
9	Parts Purchased	All members
10	Manufacturing	Abdullah & Omar
11	Testing	All members

Table 8: Assigned Members for Each Task

5.2 Contribution of Team Members

Each member's contribution and their willingness to work was discussed in our first meeting as a team, and the tasks were divided and agreed upon by each member.

Table 9 shows how much work each group member contributed, as a rough percentage.

S. No.	Tasks		Assigned Member	Contribution
1	Ch. 1: Introduction		All members	100%
2	Ch. 2: Literature Review	Project Background	Fawaz	33%
		Previous Work	Abdullah	33%
		Comparative Study		34%
3	Ch. 3: System Design	Design Constraints & Methodology	Moaad	20%

		Engineering Design Standards	Abdullah	20%
		Theory & Theoretical Calculations	Fawaz	20%
		Product Subsystems & Component Selection	Fawaz & Moaad	20%
		Manufacturing & Assembly	Moaad & Fawaz	20%
4	Ch. 4: System Testing & Analysis	Experimental Setup, Sensors & Data	Omar	40%
		Results, Analysis & Discussion	Abdullah	60%
5	Ch. 5: Project Management	Contribution of Team Members	Omar, Abdullah, Omar & Fawaz	100%
		Project Execution Monitoring		
		Challenges & Decision Making		
		Project Bill of Materials & Budget		
6	Ch. 6: Project Analysis	Impact of Engineering Solution	Moaad	100%
		Contemporary Issues Addressed		
7	Ch. 7: Conclusion & Recommendation	Conclusion	Omar	100%
		Future Recommendation		

8	Design of Prototype	Moaad	50%
		Fawaz	50%
9	Parts Purchased	Abdullah	20%
		Omar	30%
		Moaad	30%
		Fawaz	20%
10	Manufacturing	Abdullah	60%
		Omar	40%
11	Testing	All members	100%

Table 9: Contribution of Tasks

5.3 Project Execution Monitoring

To ensure the continuous progress of the project, regular meetings between the group members, to discuss the next step, and between the group members and the advisor, to take approval for said step, needed to be done on a regular basis. In addition to these meeting, we were asked to hand in progress reports and perform a presentation to explain what we have done in the project till the date of the presentation. All the dates are listed in table 10 below

Activities and/or Events	Time and Date
Assessment Class	Once a week
Meeting with the group members	Weekly
Meeting with the Advisor	Bi-Weekly
First Finished Prototype	16.02.2019
Midterm Presentation	21.03.2019
First Test of System	24.03.2019
Finishing Final Prototype	30.04.2019
Test of the System	06.04.2019
Final Submission of Report	18.04.2019
Final Presentation	18.04.2019

Table 10: Dates of Activities and Events

5.4 Challenges and Decision Making

Considering our project based on the concern of decreasing the scarcity of drinkable water, we had to go through a lot of challenges which ensured safety and hygiene of the water consumers. For such a purpose, we had to make sure every possible safety precaution was considered and no compromises are done in order to make our system effective enough to generate water that is readily safe enough for human consumption. It also provided some of the very deep insights on how to improve the efficiency of our system by sacrificing some of the parameters and making sure the budget stays as minimum as possible since we are aiming to expose our prototype for the people with limited finance.

5.4.1: Equipment and Device Problems

- **Heat Sink**

In our first prototype we used the heat sink enclosed in a wooden box but as it turned out the box was interfering with the heat sink performance and soon we had to change the overall design of the system so no water stays stagnant inside and trickles out.

- **Thermoelectric**

Since, our project will use the humidity in the atmosphere to condense and generate water from such a source, we had to make sure that our thermoelectric Peltier functions properly and effectively. Upon selecting one small 24 square centimeters of Peltier, the production was very slow and reach 7 hours of producing some 15 mL of water. To tackle that problem the thermoelectric were increased and a larger surface area was provided to speed up the water production.

- **Base/ Platform**

In our first prototype, the generator was box shaped and can be placed anywhere with ease and proper stability. However, upon noticing that most of water produced stays and remains within the compartment, we had to notice and take some measures on improving the water transfer from within the compartment outside to a water reservoir.

5.4.2: Testing & Safety Issues

The system we managed to come up with haven't had a lot of safety issues apart from being careful with the hot side of the thermoelectric cooler because it was easily bruise or injure someone if the system is handled in appropriately while in operation. Moreover, we had to manage some proper grounding of wires to avoid electrocution if someone comes in contact with the exposed heat sink.

As far as testing is considered, there weren't any major problems apart from keeping track of water production since it does consume a significant amount of time to actually produce some.

5.4.3: Design Problems

We had to undergo several design changes due to improper insulation, improper arrangement of the whole system which was actually accumulating water inside the compartment instead of storing it inside the water container. So, in order to deal with such problems our prototype went through numerous modifications. Also, temperature management was a huge concern, for which we intended to make use of a digital thermostat to control the humidity and water production. Especially when the environment is not controlled, the water production was effected negatively and the ambient conditions were interfering.

5.5 Project Bill of Materials & Budget

The table below illustrates the parts we purchased and the amount given to the third party for manufacturing some of the intricate parts for us. It includes the total amount spent in our project in Saudi Riyals (SAR).

Table 11 shows the amount of money paid for each part in Saudi Riyals (SAR).

Material	Cost /SAR
Galvanized Steel	105
4 x Thermoelectric	80
5 x Fan	150
2 x Large Heat Sink	64
4 x Small Heat Sink	24

Welding and Manufacturing	180
Temperature Sensor	60
A.C. to D.C. Inverter	100
Humidity Meter	100
Extension Wire	8
Total Sum	871

Table 11: Bill of Materials

Chapter 6: Project Analysis

6.1 Life-Long Learning

As senior students of our institution, we had to make sure to utilize all our knowledge and to challenge ourselves of how much have we learnt over the past few years. This also includes, that we had to undergo some of the difficulties we weren't ready to encounter but that is how we would be able to fight back strong and accomplish the goals we managed to set for over these three months of pure dedication and hard-work. Furthermore, it has and will refine us as a person because we gained the knowledge of how to lead as a team and completely abide by the timelines set for each task and with all due respect, it has been a extremely helpful for us now and in our future.

6.1.1: Software Skills:

As mechanical engineers, the most basic platform to begin our designing starts from designing on computer-based software especially SolidWorks. Over the semesters we have earned the necessary skills to successfully design any prototype and simulate the conditions we would be planning to work in. Moreover, we also made use of MS excel to record data and illustrate them in a comprehensive graph which speaks better than words.

6.1.2: Hardware Skills:

In order to conduct and perform experimental tests, we have managed to successfully made use of hardware equipment such as a humidity meter to measure the moisture content to give us an idea of the how much effective is water production going to be. Moreover, as a hardware device, digital thermostat was also used for the sake of properly detecting and varying the temperature within the compartment for proper temperature to facilitate humidity.

6.1.3: Time Management:

We had about three months of total time to complete the project, we really needed to manage our time in an efficient manner in order to be ahead of time for unpredicted difficulties and obstacles we might face. Thankfully, all group members were in close contact and everyone was on the same page when making decisions, which really helped with cutting time and utilizing it effectively.

6.1.4: Project Management:

In achieving something of this big task as our project, we needed a proper plan and time management so every task can be accomplished in a timely fashion. It also shows us the properly managed teamwork among us all as a group because without proper communication, understanding, dedication and commitment with responsibility it was not possible to achieve the amount of goals set for us and our group.

6.2 Impact of Engineering Solutions

6.2.1: Society:

As the project we selected already was biased towards the vast majority of people being unable to consume clean drinking water in most of the developing or under-developed countries globally, we ensured that our project can be constructed in such a way that it requires very less financial support to produce. Once produced successfully, the common majority can drink the water being generated from the humidity present in the surrounding atmosphere.

6.2.2: Economy:

Similarly, the amount of money spent in this project is not too much for a prototype. But it can be refined a lot for just the fraction of amount we have used in order to make this prototype possible. With more refined tuning and proper optimization of the system, it would be a great deal of worth for what we have achieved in order to solve world thirst for water.

6.2.3: Environment:

Since our project is to serve the humanity in trouble and deficiency of water, we have already taken care of the environment as well as it does not really produce any pollutants and does not even produces waste that would harm the environment. Instead, it uses the environmental source i.e. humidity present in the air to condense and generate water which I guess is very environmental friendly and one of the very effective ways to contribute in saving the environment and mankind from thirst in one go.

6.3 Contemporary Issues Addressed

Looking toward the past and then gazing towards the near future, we are almost confident enough to declare ourselves in which we have contributed towards the major society to utilize the natural environmental source to obtain something as precious as water for our basic necessities and especially thirst. However, not everything can go and achieved in a perfect manner and there is always that one spot which can be troublesome and to address some in our opinion, we think that the project may need some optimization as it consumes a lot of time to produce water and also it can work in it's peak performance where the weather is prone to be humid in the mid of the year. So, this can give one clue that our prototype is well suited to coastal regions where there is an immense possibility of humidity.

Chapter 7: Conclusion & Future Recommendations

7.1 Conclusion

In a nutshell, our project has been a very big challenge especially considering that there has been previous done already in the past but with a lot of budget in the bank. However, we challenged ourselves to do the same but with the least amount of budget being spent on our system because we are aiming for the majority who do not have financial means to afford such big systems which can generate water from atmosphere. But, all things considered, we as a group did what was unachievable in the time frame of these three months.

And most importantly, we were able to defend our objective of this prototype which included the proper production of drinkable water where there is no access to clean drinking water and where the people are residing in extreme humid conditions. So, the system can successfully use the environmental conditions and parameters to be productive and useful.

7.2 Future Recommendations

There have been many things we missed out on enabling our system to be very effective and efficient with the production of water. However, since it is still in a prototype stage, there are a lot of room for improvements. One of which is, to properly optimize the system which facilitate the production of water in case of conditions where humidity can be decreased too low. Secondly, there should also be a need to properly insulate the heat sink to avoid leakage of current and heat which will eventually improve the efficiency of the whole system. Also, there would be a need of heat sink wall modification to avoid resting on it and instead is passed straight towards the water container.

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